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Portable Airborne Hazard Warning System

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Portable Airborne Hazard Warning System

Abstract:

Exposure to air pollution and other airborne hazards contributes to respiratory and cardiovascular issues, diseases, allergies, and premature death for tens of millions of people each year. Poor air quality can also impair the enjoyment of indoor and outdoor activities. As a result, there is a need to monitor air quality in real-time and warn people of any local hazards.

This publication describes systems and techniques for portable electronic devices, such as smartphones, tablets, laptops, and smartwatches, to measure and analyze local air quality. For example, a portable electronic device detects potential airborne hazards using a volatile-organic-compound (VOC) sensor and/or a particulate matter (PM) sensor. The portable electronic device, using an on-device machine-learned model, evaluates the measured data to generate appropriate alerts for the user.

Keywords:

Gas sensor, VOC sensor, volatile-organic-compound sensor, air sensor, PM sensor, particulate matter sensor, air-particle detector, pollen detector, integrated, pollution, air quality, smog, carbon monoxide, carbon dioxide, machine-learned model, machine learning.

Background:

Throughout the world, multiple forms of air pollution exist that, in excessive levels, adversely affect our health. As just one example, air pollution causes about seven million premature deaths each year. Sources of air pollution include gases (*e.g.*, ammonia, carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide, nitrous oxide, methane, volatile organic compounds (VOC), chlorofluorocarbons), organic and inorganic particulates (*e.g.*, pollen, dust, ash, smog, soot, mold spores), and biological molecules. Because real-time air-quality information is not readily available for most environments, people may not recognize that their environment is harmful until after they start to experience symptoms (*e.g.*, feel nauseous, have an allergic reaction, have impaired breathing, irritated eyes).

It is desirable to utilize portable electronic devices to provide users with real-time air-quality information and assist them in avoiding or leaving areas with poor air quality.

Description:

This publication describes systems and techniques to detect airborne hazards and provide appropriate alerts to users. Portable electronic devices are increasingly mobile and ubiquitous, while also advancing in capabilities to detect and measure various forms of input data. These features make portable electronic devices good candidates to assess air-quality information in real-time and help users reduce their exposure to airborne hazards. Figure 1 illustrates an example portable electronic device that can measure and process air-quality data.

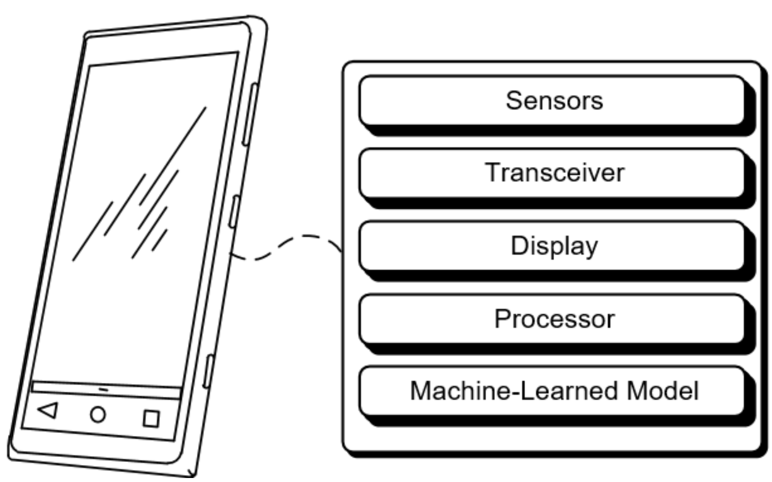

Figure 1

As illustrated in Figure 1, the portable electronic device can be a smartphone. The portable electronic device includes sensors, one or more transceivers for transmitting and receiving data over a wireless network, a processor, and a display. The sensors detect and measure a variety of input data. For example, the sensors can include a VOC sensor, a PM sensor, a location sensor (*e.g.*, a global positioning system (GPS) sensor), an accelerometer, a motion sensor, and/or a gyroscope.

A VOC sensor provides real-time air-quality information regarding the concentration of gases associated with poor air quality. For example, a VOC sensor can detect CO_2, alcohols, aldehydes, ketones, organic acids, amines, organic chloramines, and hydrocarbons present in the immediate vicinity. Engineers can integrate a VOC sensor into a surface or port of the portable electronic device that allows the sensor to obtain sufficient samples of the air in the local environment. In some cases, device manufacturers may integrate the VOC sensor into an existing port of the design for a portable electronic device.

A PM sensor detects the presence of dust particles and other airborne particulates, which generally have a size of about 2.5 micrometers. PM sensors take optical measurements and, thus, require a transparent viewing-window to assess local air quality. In some cases, engineers can place the PM sensor near the top edge of a smartphone above the display screen and behind the front glass. In this placement, the PM sensor has a sufficient viewing angle to analyze the local air while being handheld or laying down flat on a horizontal surface.

Portable electronic devices frequently utilize motion-related sensors, such as accelerometers, radar sensors, proximity sensors, and gyroscopes, to detect whether the device is moving or in a pocket. Engineers can use such sensors to control the sampling rate of the VOC sensor and PM sensor. The portable electronic device can optimize the sampling rate to conserve power in different scenarios. For example, if the portable electronic device detects that it is stationary, the sampling rate of the VOC sensor and the PM sensor is reduced, and battery power is conserved. In contrast, if the portable electronic device detects that the user has moved into a new environment (*e.g.*, based on the duration of detected movement), the device will signal the VOC and PM sensors to assess the air quality of the new area. As another example, if it is detected that the device is in a user's pocket, the VOC and PM sensors will not make measurements, thus preventing unnecessary power consumption. Similarly, the portable electronic device can implement a low-power polling sequence for the VOC and PM sensors. In this sequence, the sensors take samples every few minutes, tens of minutes, or hour.

Portable electronic devices generally use location sensors to determine their geographic location. A portable electronic device can download historical air-quality data (if available) associated with the user's location to provide appropriate alerts or assist with analyzing collected VOC- and PM-sensor data. For example, if a portable electronic device determines that it has been in a pocket and moving for a sufficient time, the device may utilize the location sensors to determine its new location and then access online air-quality data. If the location has historically poor air quality, the device will signal the VOC and PM sensors to measure the air quality as soon as the device is removed from the pocket.

Air-quality samples can be collected by the VOC and PM sensors and categorized with corresponding pollution classifications (*e.g.*, types of pollutants present, levels of particular pollutants, associated health risks) to train a machine-learned model. After sufficient training, the machine-learned model can be deployed to the operating system (OS) of a portable electronic device. Figure 2 illustrates an example of how the OS may use the VOC sensor, the PM sensor, and the machine-learned model to monitor air quality.

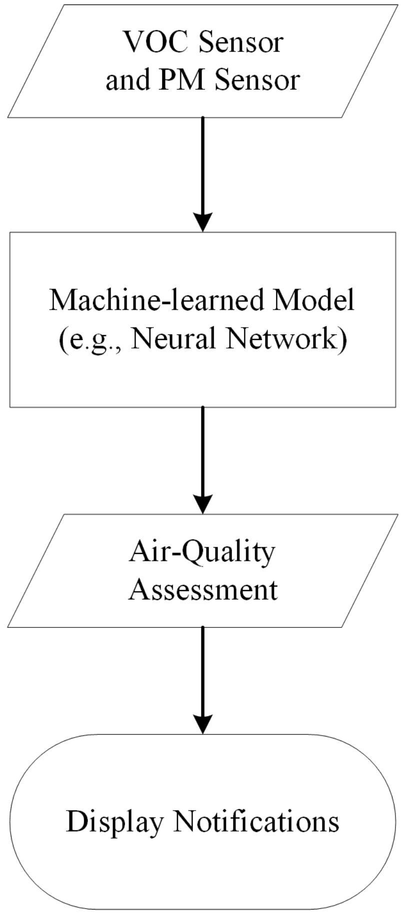

Figure 2

In Figure 2, the VOC and PM sensors periodically measure the nearby air and generate a signal with data. The machine-learned model receives the sensor data and analyzes the local air-quality. For example, the machine-learned model can use algorithms to correlate whether the sensed gas components are due to smoke, fire, or general breathing. As another example, if the VOC sensor is not able to measure a harmful gas (*e.g.*, CO) directly, the machine-learned model can determine whether the gas is present through statistical correlation, reducing the number or complexity of VOC sensors needed. The machine-learned model can also prevent false alarms. For example, while the portable electronic device is indoors and the user is cooking a meal in a usual manner, the machine-learned model can infer that a slight increase in CO is not indicative of a fire in the house.

After analyzing the local air quality and determining that the air quality is worsening or below some threshold, the portable electronic device can display appropriate notifications to the user. Figure 3 illustrates an example alert that a portable electronic device may display on a lock screen if the air quality is worsening, but not currently hazardous. In this example, the "Air-Quality App" provides an alert on the lock screen of the portable electronic device that the air quality in the user's environment is worsening. Figure 4 illustrates an example alert that can be displayed if the air quality in the local environment is critical and may cause adverse health effects. The portable electronic device can display the alert and provide audible (*e.g.*, a beep) or haptic (*e.g.*, vibration) feedback to the user.

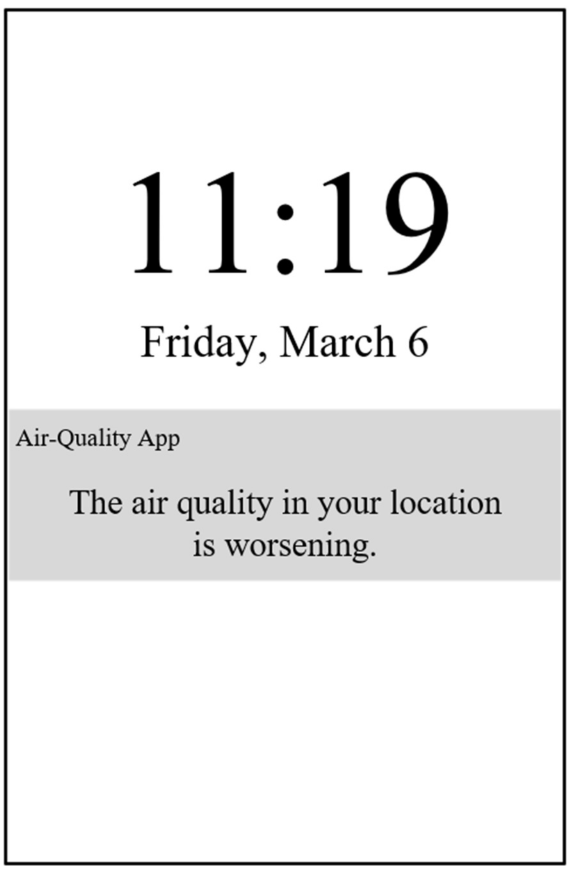

Figure 3

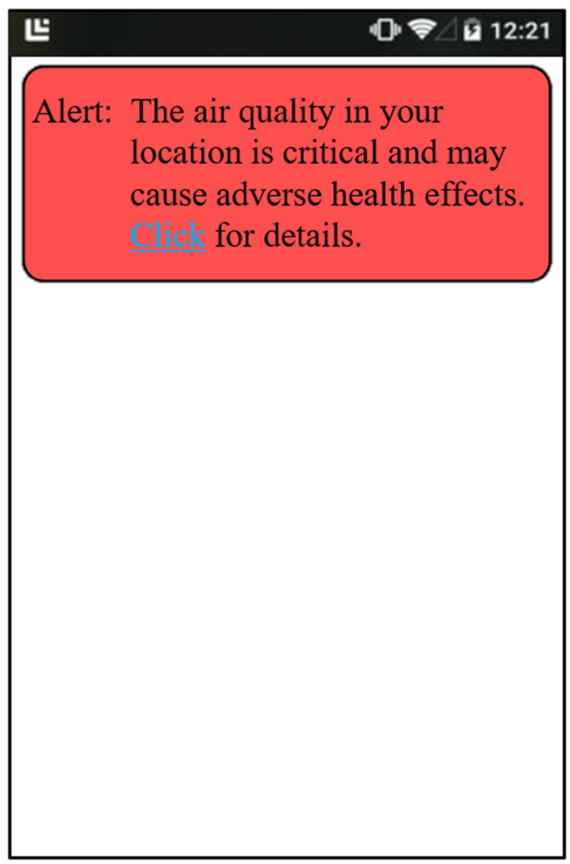

Figure 4

The described systems and techniques provide users with real-time air-quality information to mitigate the negative health effects of air pollution. The portable electronic device can also utilize a machine-learned model to minimize power consumption, improve detection capabilities, avoid false alarms, and increase accuracy.

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